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ARTICLES

SMOKE POLLUTION AND PLANTS

J. B. E. PATTERSON

National Agricultural Advisory Service, South-Western Province

The effects of the fogs of early 1953, especially when temperature inversion brought about an increase in the atmospheric concentration of sulphur dioxide and other gases of up to ten times the normal in London, have stimulated discussion on the damage produced by smoke and noxious gases given out from chimneys. Naturally the greatest attention has been paid to the effect of these on the health of humans and animals, but atmospheric pollution continuously surrounds plants in and around towns and cities. In industrial areas agriculture and horticulture are carried on only with difficulty.

Efforts towards smoke abatement are by no means of recent introduction. They date almost from the earliest substitution of coal for charcoal as a generally-used fuel in London in the thirteenth century. Queen Eleanor, wife of Henry III, left Nottingham in 1257 because she could not stand the smoke, and in 1273 Edward I made the use of coal illegal as being prejudicial to human health. The first Smoke Abatement Society was formed in 1306 by the Lords and others attending Parliament because of the annoyance of the increasing smoke ; a Royal Proclamation prohibited artificers from using coal in their furnaces and was enforced in the next year by the execution of an offender.

Queen Elizabeth I, in 1578, was " greatly grieved and annoyed with the taste and smoke of the sea-coals " so that the Company of Brewers offered to burn only wood in the breweries near the Palace of Westminster [1].

By the seventeenth century, influential and observant people in London were perturbed by the damage to trees and plants. In 1661 the diarist Evelyn wrote a pamphlet called " Fumifugium " calling attention to the damage and suggesting "A Plan for the Improvement and Melioration of the Aer of London, by way of Plantations, etc." An official inquiry was held in London in 1718, and in 1727 J. Fairchild in " The City Gardener " listed plants which used to grow in the City and would no longer do so. Since then the range has become even more restricted. It is no mere chance that the Plane tree, which annually sheds its bark as well as its leaves and so is self-cleansing, has become the typical tree of the London streets.

In spite of the interest and discussions of 650 years, little organized investigation was carried out until 1912, when a Smoke Abatement Exhibition was held and a committee was formed under the chairmanship of the Director of the Meteorological Office, Sir Napier Shaw, with Dr. J. S. Owens as secretary. The latter carried out a great deal of outstanding research work for many years. Since 1945 the Atmospheric Pollution Research Committee of the Fuel Research Board has directed the observations and research.

The By-products of Coal

According to the Statistical Digest of the Ministry of Fuel and Power for 1951, the inland coal consumption for 1923, 1938 and 1951 was, in millions of tons :

	1923	1938	1951
Collieries	16.9	11.9	10.5
Railways	14.0	13.2	14.4
Coastwise bunkers	1.4	1.3	0.9
Gas works	17.2	19.1	27.4
Coke ovens	19.8	19.1	23.6
Electricity works	7.2	14.9	35.4
Miners' coal	6.5	4.6	5.1
Domestic	93.9	45.8	32.4
Other uses, mainly industrial ...		45.7	56.2
	176.9	175.6	205.9

By the consumption of this coal we send out into the air, which we make into our greatest sewer, smoke (incompletely burnt carbon and tarry substances) ; ash and grit ; and gaseous products of combustion (carbon dioxide, sulphur dioxide, carbon monoxide, hydrochloric acid, hydrofluoric acid and silicon tetrofluoride). The last three of these gases are produced only in traces by burning coal.

Industrial factories may also emit from chemical reactions, hydrofluoric acid, hydrochloric acid, hydrogen sulphide, oxides of nitrogen, selenium, zinc oxide and other solid materials. All these are controlled by the Alkali Inspectors of the Ministry of Housing and Local Government.

The earliest work on studying the effects of smoke pollution on vegetation was done in Leeds by Crowther and Ruston [2 and 3], and Crowther and Steuart [4 and 5]. They emphasized the fourfold damaging effect of this in reducing the solar energy falling on leaves, blocking of stomata and consequent reduction of assimilatory power of leaves, direct damage by acids deposited in rain and absorbed by tissues as gases, and in changes brought about in soil by acids. Each of the constituents listed earlier produces a series of effects harmful to plants.

Smoke and Tarry Substances

Reduce light intensity in the atmosphere and so prevent its reaching the leaf.

Coat the surfaces of leaves and so form a further physical barrier to photosynthetic processes.

Increase the adhesion of dust particles to leaf surfaces.

Block the stomata of the leaf.

Coat the glass of greenhouses and so again reduce the amount of solar energy reaching plants.

Ash and Grit

Remain suspended in the air and reduce the light intensity near the ground.

Act as nuclei for condensation of moisture and so produce fog.

Coat leaves of plants, especially when these are hairy or crinkled or tarry substances are deposited on the surface.

Coat the glass of greenhouses by becoming embedded in tarry material.

Block the pores of soil on the surface and so interfere with drainage and sometimes encourage the growth of mosses.

Act as direct plant poisons (arsenic, zinc) or as poisons to animal grazing (lead, beryllium, selenium).

Ash and grit will vary considerably in size between one-tenth inch diameter near industrial stacks and less than three-thousandths inch diameter in residential areas. Most will be given off by factory chimneys, railway engines and by ships in docks.

Gases

Enter the leaves of plants through the stomata.

Dissolve in suspended droplets of moisture in the air, or in rain or dew, and are deposited in solution on leaf surfaces.

Dissolved in rain or dew, fall on to the soil and steadily leach out soil bases and lower the soil *p*H.

Of the gases which occur in the atmosphere, sulphur dioxide is by far the most toxic to plants.

Effect of Solid Particles on Plants

The effects of pollution vary from mild retardation of growth to severe damage to plant tissues and even death. Plant species vary considerably in their resistance to damage. Conifers suffer more than any other species because their characteristic sunk stomata readily collect the solid particles. Evergreens are particularly susceptible, as also are species such as grasses, winter lettuce and spring cabbage, which are active in winter—the period during which most coal is burned and the atmosphere pollution is greatest. Any type of leaf which is crinkled or hairy will readily hold tarry deposits and solid material. Because of the reduced photosynthesis, some evergreens may not flower, and where deposits are severe will become deciduous. Cohen and Ruston [7] found that three miles to the north of Leeds,

privet was evergreen and produced flowers, but at two miles flowering did not occur, and at one mile the bushes were almost completely defoliated in winter. At the city centre the leaves fall in January, while in the industrial section they fall in November.

Wareing [8] has shown recently that growth in the third year of Scots pine is affected by the light received in the previous year. If this holds good for other evergreen plants, as seems reasonable, it will readily be understood how gradual degradation and death of evergreens take place. Rhododendrons, yew and holly retain their leaves for between three and seven years in a clear atmosphere, but both the length of annual shoot growth and the period of retention of leaves become shorter as pollution increases.

The chemical composition of grit and ash is complex and these materials probably have toxic effects on plants. Grit collected from leaves of geraniums growing in a public square in the middle of Bristol was found by spectrographic analysis to contain significant amounts of beryllium and lead, as well as c pper, aluminium, zinc, tin and manganese.

Damage by Gases

Important as are the tarry and gritty components of pollution, the gases, especially sulphur dioxide and, in a lesser degree, hydrogen fluoride, probably play the greatest part in damaging plants. The average sulphur content of coal is about 1.5 per cent, so that the 206 million tons of coal burnt in this country each year produce at least 6 million tons of sulphur dioxide—equivalent to 9 million tons of sulphuric acid [1]. Of this sulphur dioxide, about $3\frac{3}{4}$ million tons are retained on buildings and vegetation.

Large-scale damage to vegetation by sulphur dioxide near smelting works has been the subject of two commissions. The report of the first commission was published in 1915 and dealt with pollution in California [9]. The second, and more recent, commission investigated damage at Trail in British Columbia, and the report was published in 1939 by the National Research Council of Canada.

In the industrial regions of the north the quality of pastures is naturally poor (mainly fescue-agrostis and Yorkshire fog), especially on the hill land above the towns and factories. Trefor Jones [6] described how this is due largely to neglect, which results from the overwhelming obstacles encountered by the farmer in preventing reversion of pastures sown to good seeds mixtures. Cocksfoot, crested dogstail and meadow foxtail barely hold their own, while perennial ryegrass and wild white clover do not survive. During the last war attempts at improving hill pastures in East Lancashire were successful at first, but the productivity rapidly declined and the land soon reverted to its former poor state, in contrast to the permanent improvement found on hill lands in more rural parts of the country. Bleasdale [11], under the auspices of the Agricultural Research Council and the Manchester City Health

Department, investigated the problem with special reference to S.23 ryegrass and lucerne ; he has offered an explanation of the mechanism of the action of sulphur dioxide.

Action of Sulphur Dioxide

Leaves readily absorb sulphur dioxide which dissolves in the cell water ; little remains on the surface, except when they are wet. The effect depends on the rate of absorption. If this is slow, the sulphur dioxide may be oxidized to sulphate as quickly as it is absorbed and immediately neutralized by the organic bases. The process continues until relatively large amounts of sulphate have accumulated and have reduced the buffer capacity of the leaf without altering the *p*H of the tissues. In lucerne, 97 per cent of sulphur dioxide absorbed in this way can be accounted for as sulphate. When the buffer capacity has been exceeded the leaf becomes chlorotic, ceases to function and falls off.

If the rate of absorption is fast, the buffer capacity is rapidly exceeded and the plant cells are injured at a much lower level of concentration than the saturating level of sulphate.

Any accumulation of incompletely oxidized sulphur radicles will inhibit cell division and growth, which are normally maintained by sulphydryl compounds. In summer the rate of cell division and concentration of $-SH$ compounds is high, so that the plant can resist damage more than in the winter, when physiological activity is low and the rate of senescence of tissues may easily be less than the rate of replacement, so that the plant will die of carbohydrate starvation.

Trefor Jones described the symptoms of damage to wheat as scorching of the leaf tip, followed by yellowing and death. Generally this effect is produced in cereals and grasses by steady absorption of sulphur dioxide over a long period. In high concentrations, acute symptoms are found which include collapsed marginal or intercostal areas with, at first, a dull water-soaked appearance, later drying out or bleaching to an ivory colour in most species, although brown or brownish-red colours are also found. The degree of damage depends on the humidity and is greater under conditions following high physiological activity.

When the concentration of sulphur dioxide in the air is greater than 0.5 parts per million, visible damage occurs to plants. Prolonged exposure of S.23 ryegrass to between 0.01 and 0.06 p.p.m. was shown by Bleasdale [11] to reduce the dry matter contents of the leaves to 45 per cent of that of similar plants grown in purified air. Exposure to sulphur dioxide stunts growth by lessening cell division and elongation, and reduces the vigour of plants, thus lowering their resistance to frost, winds, soil acidity and the toxic effects of insecticides and fungicides. Potatoes sprayed with Bordeaux mixture against blight infection have been killed by copper toxicity in areas where sulphur dioxide pollution has weakened their resistance. Reproductive

capacity is reduced : seeds of oats grown outside Leeds had a germination percentage of 98, whereas the figures for plants grown in the city and the industrial area were 68 and 17 per cent, respectively. Loss of vitality also affects the physiological processes in plants, so that they may bear flowers of paler colour than usual.

Of agricultural crops, the most sensitive to sulphur dioxide is lucerne, followed by grasses, clovers, cereals and overwintering crops such as cabbage and kale.

Horticulture and market gardening suffer from atmospheric pollution ; the cost of running holdings near industrial cities is a burden heavier than is often realized. Tarry matter and solids not only reduce ultra-violet and visible radiation while suspended in the atmosphere, but are deposited and firmly held on glasshouses so that they must be cleaned off two or three times a year at great expense, for ordinary washing is almost useless. Scrubbing with hydrochloric acid is usually necessary.

Sulphur dioxide has striking effects on some species of flowering plants. Coleus is sensitive, especially the varieties " Sunset " and " Golden Bell " [12], and some varieties of begonia completely shed their leaves and flowers when exposed to low concentration for an hour or two. Of garden flowers gladiolus, polyanthus, forget-me-not and wallflower quickly suffer damage, while among shrubs rhododendron, privet, laurel, holly, yew, hawthorn, ash and conifers are difficult to grow satisfactorily.

Effect of Other Gases

The other gases mentioned earlier occur very much less frequently in the atmosphere and are nearly all very much less toxic than sulphur dioxide. Values for visible damage to plants are given as 50-100 p.p.m. for hydrogen chloride (although sugar beet is sensitive to 10 p.p.m. after a few hours exposure), 25 p.p.m. for oxides of nitrogen, and 40-400 p.p.m. for hydrogen sulphide. Elementary chlorine, however, is more toxic than sulphur dioxide.

Hydrogen fluoride may be emitted locally near brickworks, superphosphate factories and aluminium factories. The effects on plants are generally similar to those produced by sulphur dioxide, especially in that conifers are more sensitive than hardwood species. European larch is severely affected, followed by Scots pine, Norway spruce and Corsican pine, which seems to be immune [12]. Of flowers, some varieties of gladiolus are particularly sensitive [13], and this species is used in America as an indicator plant for fluorine toxicity. So far in this country the effect on animals has overshadowed that on plants.

It is possible that local concentration of ethylene may occur near gasworks or where there are leaky pipes. Oxidation products of olefines as well as carbon monoxide may be produced in exhaust

gases of internal combustion vehicles, and all of these cause abscission of leaves and flowers.

The chief and most obvious remedy for all damage caused by atmospheric pollution is to prevent the emission of harmful solids and gases, and this is becoming more and more a matter of public interest which is likely to lead to legislation. In the meantime, good husbandry on farms will ensure that crops are maintained in a healthy and vigorously growing state so that they will have resistance to damage. Horticulturists can seal up the cracks in glasshouses and keep the temperature and humidity in the houses as low as possible, while ensuring that the chimneys of the boilers are not of such a height as to feed the gases they give off straight back into the ventilation system of the houses.

With a better understanding of the size and nature of the problem of preventing atmospheric pollution, we may hope for results from the willing collaboration of industry, local authorities and agriculture.

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THE PRODUCTIVITY OF LABOUR IN FARMING

H. T. Williams

Ministry of Agriculture and Fisheries

Broadly speaking, the real and fundamental costs of all goods and services can be reduced ultimately to terms of hours of human effort. It is recognition of this fact which has led to the problem of improving the well-being of mankind being viewed, in recent times, as largely a problem of increasing the productivity of labour. The more that can be obtained from each hour of effort expended, the more are we able to consume or make available to exchange for commodities produced by others; or yet again, the greater the benefits that can be enjoyed in the form of leisure.

The case for increasing productivity stated thus simply is probably true for a world in which there are no impediments to trade and exchange. For individual countries and for particular industries, however, it may need to be modified. For agriculture in particular, it has had to be substantially modified, and it is no accident that in this country output per acre has tended to be emphasized rather more heavily than output per man. Traditionally this has arisen from the high density of population in relation to land and from the fact that the products of farming are essential to life itself. In times of pressure, such as war, or during the aftermath of war, when other sources of food are denied to us either by physical or financial means, the emphasis on output per acre has been even further increased and interest turns to the total production of food rather than production per man. At such times means of increasing production per man which would tend to reduce output per acre would not find favour. Despite this, however, it is wrong to suggest that there is a conflict between output per man and output per acre, because in any circumstances it is obviously to everyone's advantage, whatever the level of total home production of food that is needed, that it should be produced with the minimum of manpower. It is only in this way that manpower can be made available for producing all the other goods and services necessary to support a tolerable standard of life.

At the present time the Government of this country has asked farmers to expand production to a level 60 per cent above pre-war. Although this obviously entails increasing output per acre, farmers and farm workers will only serve the national interest fully if they achieve this intensification of farming without calling upon additional labour and, if possible, with less labour, as in fact they appear to be doing. While increases in productivity in farming would mitigate the effects of the drift from the land, they need not accentuate it, since each such increase enlarges the scope for the profitable employment of workers in agriculture.

Increasing the productivity of labour is not, however, just a matter of national economics. It is a matter of great and direct importance to

employers and workers as individuals. The level of remuneration of each at any particular time will be governed by a wide range of factors, but the total to be divided between them, which is clearly the most important limiting factor, is determined by the surplus of output over input brought about by their efforts in their respective spheres of work. The larger the surplus or—what is the same thing—their productivity, the greater the potential return to each.

It may, therefore, be interesting and profitable to look back at the changes which have occurred in British agriculture during the past fifteen years or so to see how these have affected the productivity of persons engaged in the agricultural industry, and to see if any lessons for the future may be learnt.

Changed Pattern of Farming

There is no need to elaborate in detail the changes in the pattern of farming which the necessities of war and the difficult economic and financial conditions of the peace which followed have forced upon us. We generally think of these changes in terms of the commodities produced—crops and livestock products for human consumption—but in assessing the achievement of farmers and workers it is equally, if not more, important to think of them in terms of changes in the kind of work which they entailed. Table 1, which shows the proportion

Table 1
Changes in Distribution of Agricultural Work, United Kingdom 1937-39 to 1952-53

Year	Percentage of Total Labour expended on				Total Labour
	Sale Crops		Livestock		
	Farm Crops	Horti-cultural Crops	Fodder Crops	Attend-ance on Livestock	
1937–39*	9	10	23	58	100
1939–40	9	12	25	54	100
1940–41	12	10	29	49	100
1941–42	13	10	32	45	100
1942–43	15	12	30	43	100
1943–44	16	11	29	44	100
1944–45	14	12	28	46	100
1945–46	14	11	29	46	100
1946–47	14	12	28	46	100
1947–48	12	13	25	50	100
1948–49	14	12	25	49	100
1949–50	12	12	25	51	100
1950–51	12	13	24	51	100
1951–52	11	12	25	52	100
1952–53	11	12	24	53	100

* Average

of the total man-hours worked each year devoted to different kinds of farm work, gives a broad outline of what happened. The rise and fall in the proportion of labour absorbed by arable crop production before and after the period 1941-44 and the converse changes on the livestock side are well brought out. I think it can be inferred from these figures that by 1942-43, or thereabouts, quite a few farmers were practising forms of husbandry in which, to say the least, they were not particularly experienced.

It was not, however, just the pattern of farming which changed. There were also changes in the scale of farming and in the numbers and kind of people available to do the job. I have tried to express changes in scale by giving the gross output of farming in each year in terms of the hours of work it would have entailed in a base year, and converting these figures into an index with the period 1937-39=100. The index is shown in the second column of Table 2. Between pre-war and 1952-53 the scale of farming measured in this way increased by 30 per cent. In other words, the gross output of farming in 1952-53, assuming that the productivity of labour had not changed, would have needed 30 per cent more man-hours than the average gross output produced in 1937-39. (This figure, based on labour requirements, is calculated in quite a different way from, and is not directly comparable with, the Ministry's official index of net output, which showed an increase of 51 per cent in 1952-53.)

The changes in the composition and size of the labour force were also substantial. The number of regular men workers declined to a low level in 1943-44 but, largely as a result of the formation of the Women's Land Army, the number of regularly employed women increased ; and there was also quite a large increase in the employment of casual workers, both men and women. During the last year of war and the first two or three years of peace some use was also made of prisoners of war. Since the war these changes have operated in the reverse direction, and now we are again back to approximately the pre-war structure and size of labour force, as measured by numbers of people employed. The qualification in the latter part of the previous sentence is significant, because in one important respect we are not back to pre-war. Since 1945-46 there have been several decreases in the basic hours of work to which the statutory minimum wage applies and, in general, actual hours of work have tended to decrease by a similar amount.

Greater Effectiveness of Labour

To understand these changes in the composition of the work force, it is necessary to take some account of the varying skill and capacity for work of the different classes of workers, and there is probably no better indicator of these differences than the average earnings per week or per hour of each kind of worker. On the basis of earnings, therefore, the labour force in each year has been converted into man-equivalents,

distinguishing between man-years and man-hours. The figures are shown in the third and fourth columns of Table 2. Labour in terms of man-years, after increasing to a level 9 per cent above pre-war in 1944-45, has decreased to about 100 per cent in 1952-53. Since 1952-53 there has been a further loss of workers and the index now stands a little below 100. Detailed figures on hours of work are not available for the earlier war years, but towards the end of the war, hours worked per person were about the same as pre-war. Since 1944-45 there has been a continuous decline, and in 1952-53 the index based on hours worked was about 7 per cent below pre-war.

Table 2
Indices of Gross Output, Labour Input and of Productivity

Year	Index of Gross Agricultural Output in Terms of Pre-war Labour Requirements	Index of Labour Input		Index of Productivity	
		Per Man-Year	*Per Man-Hour*	*Per Man-Year*	*Per Man-Hour*
1937–39*	100	100	100	100	100
1939–40	107	99	—	108	—
1940–41	100	101	—	99	—
1941–42	92	103	—	89	—
1942–43	103	107	—	96	—
1943–44	106	108	109	98	97
1944–45	104	109	109	95	95
1945–46	106	107	106	99	100
1946–47	104	108	103	96	101
1947–48	111	108	103	103	108
1948–49	120	108	102	111	118
1949–50	121	105	99	115	122
1950–51	122	103	97	118	126
1951–52	127	101	94	126	135
1952–53	130	100	93	130	140

* Average

With Column 2 of the table measuring the output of each year in terms of pre-war labour requirements, and Columns 3 and 4 measuring the actual input in each year, we can get a measure of the increase in productivity a man-year or a man-hour by dividing Columns 3 and 4 respectively into Column 2 and expressing the answer for each year as a percentage of pre-war. The index of productivity per man-year is given in Column 5 and per man-hour in Column 6. From these figures it can be seen that the productivity of labour was generally below the pre-war level until after the war, but since 1946-47 there has been a continuous increase, with productivity per man-hour increasing more rapidly than per man-year. In brief, what these figures mean is that the average year spent in farm work is now 30 per cent more effective than it was before the war, while the average hour of work on the job is 40 per cent more effective.

Other Productivity Factors

Measures of the productivity of labour calculated in this way are a little over-simplified and they can be misunderstood. The most common error is to assume that the change has been brought about simply by harder work and effort. But, in fact, in agriculture more than any other industry, we have an extremely wide range of inputs —feeds, fertilizers, machinery, fuel and so on—which, according to the use made of them, also influence the level of output. Equally important in year-to-year comparisons, we have seasonal variations due to weather conditions in the yields of crops and livestock products. Now the measures of productivity given above have been influenced by all these factors and represent the sum total of the effect of all these factors on the level of output per man or man-hour, or—what is the same thing—on the productivity of labour.

The effect of these other factors on productivity can hardly have been negligible. In Table 3 the quantity of the main agricultural inputs in each year have been expressed as percentages of pre-war. Imported feedingstuffs, the corner-stone of pre-war livestock production, declined in the middle war years to about one-fifth of the pre-war tonnage and in 1952-53 they amounted to only about one-half of pre-war. The volume of machinery in use on farms, on the other hand, has increased by about two-and-three-quarter times. Within this average for all kinds of machines, tractors have increased five-fold and the fuel consumed by them has increased by nearly the same amount. The change in power to accomplish certain kinds of work brought about by mechanization on this scale is enormous and is indicated by the fact that, taking into account all the horses, tractors and ploughs on farms before the war and in 1952, it is estimated that the ploughing capacity of the U.K. farm workers has increased from something of the order of 400,000 acres a day before the war to 1,300,000 acres a day now. Put in another way, the pre-war arable acreage represented, at that time, about thirty days of ploughing; the 1952 arable acreage, which was nearly 40 per cent greater than the pre-war acreage, represented only fourteen days of ploughing. The capacity for field work other than ploughing has probably increased by a like amount, and it is only in care and attendance upon livestock that mechanization has not added greatly to the power of the worker. This lag in mechanization of work connected with livestock should not, however, be over-emphasized. Taking milk production as an example, of the total labour involved, not more than half is expended in care and attendance, the other half being spent on field work of one sort or another. The rate of increase in mechanization has tended to flatten off during the last two or three years.

The other great change has been in the use of fertilizers and lime. The total of all kinds of fertilizers used increased by about a half by the middle war years and, because of limitations of supply, continued at round about that level until the end of the war. Since the war the

increase has been resumed and the quantities now applied each year are about two-and-a-half times as great as before the war. Of the individual fertilizers, nitrogen has increased most—to three-and-a-half times the pre-war quantity.

Table 3
Changes in the Main Items of Agricultural Inputs
(United Kingdom)

Year	Imported Feeding-stuffs	Machinery Depreciation	Fuel	Fertilizers and Lime			
				N	P_2O_5	K_2O	C_aO
	Based on Tonnage	*Based on 1945–46 Prices*	*Based on Quantity*	*Based on Quantity 1938–39*	*1938–39*	*1938–39*	*1938–39*
Pre-war Average	100	100	100	100	100	100	100
1939–40	90	111	109	129	115	113	77
1940–41	59	126	145	213	137	63	82
1941–42	36	147	182	280	169	82	97
1942–43	19	158	218	285	178	97	136
1943–44	18	174	236	303	202	138	157
1944–45	21	179	264	287	203	153	143
1945–46	28	189	282	274	210	148	151
1946–47	21	189	309	273	209	143	116
1947–48	28	205	345	308	233	236	174
1948–49	36	205	373	308	246	261	204
1949–50	46	221	409	375	270	312	242
1950–51	47	247	427	359	245	302	192
1951–52	51	263	455	302	163	226	179
1952–53	52	268	464	358	223	267	211

This catalogue of quantitative changes in inputs is not exhaustive but it is enough to show how substantial the changes have been. Part of their effect is no doubt illustrated in the changes in yields of crops and livestock which have occurred, but in this respect due credit must be given to the contribution made by science in developing high-yielding varieties. That improvements in yields of crops have contributed materially to increased productivity is well known but in the case of eggs and milk, particularly the former, the recovery from the dislocation caused mainly by inadequate concentrated feeds has been slow.

Ideally, the contribution to agricultural productivity made by the use of resources brought in to agriculture from other industries and professions should be eliminated in order to obtain a measure of the contribution made by agriculture alone. Unfortunately, there is no really satisfactory way in which this can be done so as to give completely unambiguous answers, but there is a way in which things can be narrowed down a little.

Relation of Labour to Total Production

In addition to relating the labour input to gross output, which is the aggregate result of all the contributory elements (as has been done in the indices in Table 2), we can also relate labour to (*a*) the acres of crops and grass grown and numbers of livestock kept, and (*b*) the total production of all farm products, including crops grown for feed. Using acres of crops and grass and numbers of livestock as the measure of the amount of work done, the effect of improvements in yields over the period are eliminated and the index of productivity resulting will come near, at least, to measuring the contribution to productivity made by more machinery and a general improvement in the management of men and machines. Relating labour to total production brings in the influence of improved yields but it does not bring in certain improvements in management, e.g., improvement in the conversion of grass or other home-produced foods to livestock products, or the elimination of waste which are then broadly equal to the difference between this index and the final one on gross output. The figures are shown in Table 4.

Table 4

Comparison of Indices of Productivity based on Acres of Crops and Grass and Numbers of Livestock, Total Farm Production and Gross Output

Year	Index of Productivity based on Acres of Crops and Grass, and Numbers of Livestock		Index of Productivity based on Total Farm Production		Index based on Gross Output of Agriculture	
	Per Man-Year	*Per Man-Hour*	*Per Man-Year*	*Per Man-Hour*	*Per Man-Year*	*Per Man-Hour*
1937–39*	100	100	100	100	100	100
1939–40	103	—	105	—	108	—
1940–41	103	—	99	—	99	—
1941–42	104	—	94	—	89	—
1942–43	101	—	98	—	96	—
1943–44	102	101	98	97	98	97
1944–45	102	102	94	94	95	95
1945–46	104	105	101	102	99	100
1946–47	103	108	96	101	96	101
1947–48	105	110	98	103	103	108
1948–49	108	115	111	118	111	118
1949–50	112	119	113	120	115	122
1950–51	113	120	116	124	118	126
1951–52	113	121	122	131	126	135
1952–53	115	124	126	135	130	140

* Average

The picture we get for 1952-53 is that mechanization and skill in organizing men and machines contributed about 15 per cent per

man-year and 24 per cent per man-hour to productivity. This achievement should be viewed against the background of a great increase in tillage area and the taking of the plough to areas and parts of individual farms which, before the advent of wholesale mechanical power, would have been too difficult to tackle. Taking into account yields, the increase in productivity has been 26 per cent per man-year and 35 per cent per man-hour. How far yields may be due to improved varieties and the efforts of the scientist, and how much due to improved cultivations, sensible use of fertilizers and so on, cannot be estimated, but the contribution of all these influences together has clearly been quite substantial. Finally, the index based on gross output adds another four and five points to the man-year and man-hour indices, respectively. The factors which have contributed to these few additional points are probably numerous and would vary greatly from farm to farm, but amongst them are probably elimination of waste on the farm—whether this be waste of fodder crops grown or their inefficient feeding to livestock. All improvements in management which increase the production made available for human consumption increase productivity. There is no space to deal with the varying relationship between the different indices at different times and, in fact, these varying relationships are not capable of statistical explanation. Indeed, at this point it should be said that although the effect on productivity of various developments have been separately measured, in practice on the farm the developments are integrated one with another, and the effect appears as the result of improvement in general farm organization and management.

In so far as these indices sum up the experience of the past fifteen years, the points which stand out are, first, that increases in productivity are more a product of brain than brawn. Hard and conscientious work is, of course, necessary, but the real gains come from the intelligent use of the resources put at the disposal of the agricultural industry by the engineers, scientists and workers in other industries. In other words, the responsibility rests very heavily on the management. Secondly, the improvement in yields has been a very significant contributor to increased productivity, but an examination of information on yields makes it clear that the improvement on the crop side of farming has greatly outpaced the improvement on the livestock side. This constitutes a challenge to the livestock producer and his advisers, and they should bear in mind that in so far as increased productivity can be achieved through better yields resulting from careful breeding, feeding and better day-to-day management, it need not involve appreciable capital cost. Finally, although the increases in productivity in agriculture indicated by the figures given in this article are probably as high as any which have occurred in the world, there is still scope for improvement, and it is incumbent on everyone concerned to do their utmost in this direction in their own interests, no less than in the national interest.

SOIL-BORNE DISEASES AND CROP ROTATION

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Before the balance of nature was disturbed by man, serious pest and disease attacks were rare. There are several reasons for this. In the first place, plants lived scattered in mixed communities, not, as planted by man, in large areas of one crop, so that the chances of excessive multiplication in a susceptible host were much less. Then, pests were kept down by their natural enemies—for example, birds and predatory insects. Man, by destroying the enemies' natural habitat and by other operations, has often removed this control. Thirdly, in the normal state the survival of plants is largely dependent on their powers of resistance to pests and diseases: susceptible varieties will die out and only the immune or highly resistant will survive. Man for his own purpose has artificially preserved some of the susceptible varieties and must pay the price in a constant war against pest and disease.

The only method open to us in approaching to some extent the balance of nature is the adoption of crop rotation—a course which will primarily be effective in the control of soil-borne pests and diseases. It will also be beneficial indirectly by enabling operations such as cultivation and manuring to be carried out more thoroughly and conveniently. These operations will benefit the establishment and growth of the plant, so that it can withstand better the attack of diseases and pests. This article is, however, concerned with the more direct effects of crop rotation on soil-borne diseases.

The Primary Aim

The most obvious aim of crop rotation is to rest the soil from a susceptible crop sufficiently long for the disease to die out. Unfortunately, it is not easy to obtain exact data on the longevity of fungus spores. Probably the longest lived of all are the thick-walled, resting sporangia of Wart Disease, which have been shown to be still viable in soil after 9-12 years. Similarly, Finger and Toe spores have been found to be viable in soil for 3-6 years. It is true there are cases of the latter disease appearing after having been absent from susceptible crops for much longer than six years, but it is usually impossible to rule out the possibility of contamination. There are also the possibilities of seed transmission and of the disease persisting in weeds.

Clover Rot, which persists by means of sclerotia, is another disease having a long period of survival. In air-dry conditions the sclerotia have been shown to survive 3-4 years, but in soil in the open they were still viable after $7\frac{1}{2}$ years. This fits in well with the generally recommended interval of 8 years. Cases of Clover Rot occurred this year following a 13-year interval from clover, but here again it is not

possible to rule out soil or seed contamination. Resting spores of Onion Downy Mildew are viable after 3-4 years. Most other diseases are shorter lived. Take-all cannot normally last more than one or two years in the absence of the host, and Eyespot three years. The sclerotia of Tulip Fire can live only one year, so that a year's rest from tulips is sufficient.

Some disease-producing fungi can live in the soil in a saprophytic manner if the host is absent. Examples are *Fusarium caeruleum*, causing Dry Rot of potatoes, *Helicobasidium purpureum*, causing Violet Root Rot, *Corticium solani*, causing potato Black Leg and Stem Canker, and *Actinomyces scabies*, causing Common Scab of potato. These soil inhabitants will not, therefore, be starved out by crop rotation, but their numbers should be kept down to a level which will minimize the damage to the crop.

When resting the ground from a particular crop, it is important to prevent the growth of " volunteer " plants and susceptible weeds. Volunteers will carry on the disease mostly in small amounts, but it must be remembered that diseases can multiply very rapidly from such small beginnings. The destruction of weeds is one of the most important operations in plant hygiene. Charlock and other crucifers enable Finger and Toe to persist and multiply ; weed grasses, such as *Holcus* and *Agrostis*, maintain the Take-all fungus ; the Clover Rot fungus can attack a number of common weeds in European countries, including forget-me-not, dandelion and field geranium, although this has not so far been observed in Britain.

Some diseases attack more than one crop, and growing these susceptible crops in succession may be as bad as growing the single crop each year. In fact, the position may be worse, as the parasite may multiply more on one crop with less harmful consequences than on the other, so that its destructive presence may be overlooked. Examples of this are Take-all and Eyespot on wheat after barley ; Violet Root Rot on sugar beet after carrots ; and Sharp Eyespot (*Rhizoctonia solani*) on rye after potatoes.

Efficacy of Standard Rotations

Let us now consider a number of standard crop rotations from the point of view of disease control. First, there is the Norfolk four-course rotation of roots (turnips)-barley-seeds-wheat. This means there will only be three seasons between successive turnip crops, which is not long enough to eliminate Finger and Toe. The same remark applies to clover in the one-year ley. It is not surprising, therefore, that Finger and Toe and Clover Rot have been, for many years, two of the commonest crop diseases in this country. The position with regard to cereal diseases is more satisfactory. The danger of Take-all and Eyespot in normal seasons is small, as there is a one-year interval between successive corn crops. In some seasons,

however, there is a danger of Take-all persisting through the seeds ley, especially if the latter does not take well and becomes contaminated with grass weeds.

A five-course rotation enables several improvements to be made from the point of view of disease control. One of the best examples is a rotation that has become popular in the East Riding of Yorkshire—namely, roots-oats-seeds-wheat-barley—which extends the interval between consecutive turnip and clover crops to four years. There is no interval between the wheat and barley, but the wheat crop will be free from appreciable Take-all damage, and the small amount of the fungus carrying over will be eliminated in the winter cultivations before the barley crop is sown in the spring. The alternative in this rotation, in which the wheat follows the barley, is not to be recommended. As already explained, barley can build up quite a severe infection for the following wheat crop, and most of the cases of Take-all that do occur are associated with this type of rotation. If it cannot be avoided, a spring wheat should be sown to enable winter cultivations to be carried out to reduce the Take-all infection. An alternative five-course rotation rather frequent in the North Riding of Yorkshire, comprising roots-barley-seeds-oats-wheat, is equally satisfactory against Take-all.

On the heavy soils of the Holderness area of the East Riding, which are very suitable for wheat, the following seven-course rotation was once common: fallow-wheat-peas-wheat or barley-seeds-wheat-oats. This has the objection of bringing in wheat too frequently and encouraging Eyespot, which, in fact, is particularly troublesome in this area. A number of variations are being considered. For example, one grower has adopted a six-course rotation of seeds-potatoes-wheat-oats-peas-wheat, which is a distinct improvement, as there are two clear seasons between each wheat crop. Another alternative is to bring in a three-year ley, as follows: fallow-wheat-peas-barley-three-year ley-wheat-oats. The substitution of spring-sown varieties of wheat is also being tried.

Ley farming rotations are all sound from the point of view of Take-all and Eyespot control: only in seasons exceptionally favourable to the disease (as 1948), would Take-all be likely to appear. Examples of some of the more common rotations are: (*a*) three-year ley-wheat-barley-barley undersown; (*b*) two-year ley-wheat-barley-hay-barley; (*c*) three-year ley-potato or sugar beet-barley-hay-wheat.

Control by Cultivations

The survival of a fungus in soil is not normally simply a question of how long resting spores remain dormant in an inert environment. The soil is a complex mixture of physical materials and many living organisms, whose inter-relations have become apparent only in recent years. Our knowledge is not sufficient to state exactly what effects different crop rotations will have on the biology of soil, but there is

no doubt these effects play an important part in disease control. For example, one of the most important soil fungi, *Trichoderma viride*, is encouraged by acid conditions and is antagonistic to several disease-producing fungi, notably *Botrytis cinerea*, *Rhizoctonia solani* and *Ophiobolus graminis*. Any measures which encourage the multiplication of this soil fungus will therefore help in the reduction of Take-all. Cultivation which aerates the soil is the best method available to the farmer. Also valuable, because of its beneficial effect on Trichoderma and similar fungi, is the addition of organic matter, as, for example, the ploughing in of trefoil in the autumn. It is to be expected that future research will throw still more light on the mechanism of disease control by crop rotation.

ABSTRACTS

ANIMAL NUTRITION

Vitamins

The distribution of members of the B- complex in the wheat grain (variety Thatcher) has been studied by workers [1] at the Cereals Research Station, St. Albans. They found that the aleurone layer is outstanding as a repository of vitamins, and also of enzymes and minerals.

Distribution of Certain B- Vitamins in the Wheat Grain
(Figures represent percentage of that present in the whole grain)

Fraction	Aneurin	Nicotinic Acid	Riboflavin	Pantothenic Acid
Pericarp + testa	1	4	5	8
Aleurone ...	31	84	37	39
Embryo ...	2	1	12	3.5
Scutellum ...	62.5	1	14	4
Endosperm ...	3	11.5	32	41

Since the aleurone layer constitutes only about 7 per cent of the total grain, the richness of the layer itself is obvious. This layer is considered to be the most abundant natural source of nicotinic acid. Bran consists of pericarp, testa, aleurone layer and a small amount of endosperm; hence, bran and other wheat feeds are important sources of B-vitamins to non-ruminants (ruminants can obtain the B- complex from microbial synthesis).

Further work on the role of vitamin E in animal nutrition has now been reported ; previous reference to this was made in this Journal (No. 19, 299-301). Pigs which were fed excessive and increasing amounts of cod liver oil—by the seventh week of the experiment the oil accounted for 25 per cent of the total diet!—developed swellings in the neck and abdomen and became unsteady in their gait [2]. Examination after slaughter showed much yellow fluid in the body cavities, and an orange-brown discoloration of the fat ; the hearts also showed some white patches (muscular dystrophy). The weight of the pigs increased from 35 to 70 lb. in the course of the trial and their appearance and appetites were normal until the beginning of the seventh week, although by then they were each eating 1 lb. cod liver oil plus 1 lb. lard per day! Although the pigs would no doubt finally have succumbed under such drastic treatment, the immunity of this species to moderate dosage with cod liver oil has in effect been demonstrated once again.

A parallel case of oedema has been reported from New Zealand [3]. Chicks about three weeks old suffered from " X " disease, characterized by swellings in neck and breast, an inability to stand, and muscles showing haemorrhages and white streaks similar to those in dystrophic mammalian muscle. It was found that treatment with pure vitamin E (tocopherol) cured the birds and prevented further incidence. Excessive use of cod liver oil could not be incriminated as the cause of vitamin E deficiency on this occasion, but it was found that in every case the birds had been receiving wheat damaged by heating after being harvested wet, and it was suggested that the cause lay in this. Recommendations were made to feed 5 per cent wheat germ in the ration or else to add a supplement containing tocopherol.

Blaxter [4 and 5] states that 7 per cent of farms rearing beef cattle in the Inverness area show an incidence of muscular dystrophy in calves. This is associated with the poor quality of the food given in winter to the dam during pregnancy, and because the calf, receiving only its mother's milk for some months after birth, has, therefore, no adequate source of tocopherol. Grass and grass silage contain 30 to 40 mg. of tocopherol per 100 grm. of dry matter, whereas swedes, mangolds, fodder beet and straw contain only about 1 mg. [6]. The disease is therefore not met with so commonly in the better fed dairy herds nor in autumn-born beef calves. The occurrence is always most severe after a long winter. Results of a field experiment are shown below. On the basis of field experience, early cases will respond to an initial dose of 600 mg. tocopheryl acetate, followed by 200 mg. daily until the symptoms disappear.

Work on the components of fat responsible for the antagonism to tocopherol showed these to be the highly unsaturated fatty acids [7]. Attempts to elucidate the action of tocopherol were made by adding to the diet various substances capable of preventing the formation of oxidation products from the unsaturated acids [8], but of these anti-oxidants only methylene blue was found to be comparable with

tocopherol. It is suggested that the protective action is associated with the maintenance of conditions permitting normal tissue respiration.

	164 Cows on 20 Farms			
	82 Dams Received no Tocopherol before Calving		82 Dams Received Tocopherol one month before Calving	
	41 Calves not Treated	41 Calves given Tocopherol	41 Calves not Treated	41 Calves given Tocopherol
Total no. of cases	11	3	2	0
Deaths... ...	3	0	0	0
Only slight involvement	3	3	2	0

Silage

Some work on the changes taking place in the early stages of silage-making has been reported from Edinburgh [9 and 10]. The protein in silage made from unwilted herbage undergoes a partial breakdown under the influence of the plant enzymes, but this process ceases after four or five days with the attainment of a steady figure. In well-made silage, about one-fifth to one-quarter of the protein may be so changed, but the nutritive value of the products is much the same as that of the original protein and, if lactic bacteria have produced a satisfactory degree of acidity, the matter rests there. If, however, acidification has been slow and insufficient, putrefactive bacteria may take over and carry the breakdown further to form less valuable, or even useless, products.

Wilting of the herbage also produces protein breakdown but, unfortunately, the smallest experimental wilting period reported [9] is twenty-four hours, by which time the dry matter had risen from 20 to 40 per cent and the breakdown had apparently reached its constant figure (16 per cent of the original protein). In field practice it is unlikely that wilting would be prolonged under good conditions, and a lesser time, accompanied by a smaller dry matter percentage (and a lesser degree of breakdown), would suffice. Thus drying in a gentle current of cool air for under two hours produced a satisfactory dry matter percentage and negligible protein change. On the other hand, there was an indication that under wet unfavourable conditions the degree of change would be very considerable.

A study of changes in the carbohydrates of the grass through wilting and ensilage [10] showed that sucrose and fructosan diminish rapidly to give glucose and fructose, and that the latter are a little more slowly oxidized or transformed to acid. One-fifth of the sugars disappeared in twenty-four hours wilting, and one-quarter to one-third had gone after the grass had been ensiled for a week. Wilting before ensilage

may be an advantage as it would result in complex carbohydrates being converted into fermentable sugars for rapid lactic acid formation in the initial stages of ensilage. Several investigators have found that wilted material produces a higher quality of silage and reduces losses. For example, Dutch workers have cut down losses to a minimum and made good silage by wilting quickly to 40-45 per cent dry matter and filling the silo in one day.

Further advantages of wilting prior to ensiling are the reduction in the amount of effluent (offensive in itself and also a source of loss of nutrients), and the control of bulk in the animal's ration. Dodsworth has found, both for cattle [11] and for sheep [11 and 12], that, when an animal is fed solely or mainly on succulent food such as silage, the appetite is controlled by the wet weight and not by the amount of dry matter. Thus less dry matter will be consumed from a wet silage than from a dry one. Dodsworth suggests that the critical point for maximum performance may lie between 20 and 25 per cent dry matter.

Experimental Work with Grass Silage

In the trial already referred to [11], three types of grass silage were compared : (*a*) Grade 1—at the long leafy stage ; (*b*) Grade 2—flowering heads just emerging ; (*c*) Grade 3—after the heads had emerged. A fourth group of cattle received (*d*) Wilhelmsburger swedes and oat straw with crushed oats. The silage, swedes and oat straw were fed *ad. lib.* but the oats were given during the last six weeks only, starting with 3 lb. daily and increasing to 5 lb. daily for the last four weeks. This feed of roots, straw and cereal ration was typical of the feeding practice in north-east Scotland.

The cattle were at grass until mid-October, when the indoor trial began, and there was a fall or, at any rate, no gain in the live weight of all four groups during the first month. The trial ended in mid-February after 117 days, but the weight increase was all made in the last 90 days. A summary of the results is shown below.

	Grade 1 Silage	Grade 2 Silage	Grade 3 Silage	Swedes and Straw
Daily gain (117 days)...	1.81 *lb.*	1.79 *lb.*	1.43 *lb.*	1.15 *lb.*
Ratio to " swedes " gain	1.57	1.56	1.24	1.0
Daily gain (90 days) ...	2.50 *lb.*	2.53 *lb.*	2.03 *lb.*	1.58 *lb.*
Ratio	1.58	1.60	1.28	1.0

The efficiency of the diets was expressed thus :

$$\text{Efficiency} = \frac{\text{Wt. increase}}{\text{lb. D.M. intake}} \times 100$$

This was calculated for four periods, each of three weeks, and the means found were (in the same order as before) 10.25, 11.23, 9.87, 5.16, the

ratios being 1.99, 2.18, 1.91, 1.0. On this basis there was no significant difference in the efficiency of the silages, but all were much superior to the swedes. However, on the daily gain basis, the silages of Grades 1 and 2 were more effective than that of 3, because they were eaten to a greater extent and the dry matter intake was greater in their case. The writers suggest that, when the silage on a farm is of variable dry matter content, the wetter portions should be fed to store stock and the drier material reserved for those at the fattening stage.

The paper just reviewed appears in a modified form in *Scot. Agric.*, (1952, **32,** 137-41). A later trial reported in the same journal [13], compared four rations made up as follows : (*e*) swedes, straw, hay and oats ; (*f*) swedes and straw in morning, silage in evening ; (*g*) silage in morning, swedes and straw in evening ; (*h*) silage only. The rates of gain were (for 134 days) 1.08, 1.02, 0.65 and 1.10 lb. respectively and (for 97 days) 1.55, 1.43, 1.12, and 1.59 lb. The gains are noticeably smaller than those of the work previously described. The slight difference between the results of rations (*e*) and (*h*) as compared with that between (*a*), (*b*) or (*c*) and (*d*) is partly explained by the fact that the silage used was considerably lower in dry matter ; the dry matter intake was also lower. No explanation could be advanced for the poor result in (*g*), and further work will be carried out on this aspect ; the appetite of the animals in this group was less than that of the others. Other references to work by the Aberdeen School can be found in the papers quoted and also in *J. Brit. Grassl. Soc.*, 1952, **7,** 151-9.

Apart from the value of grass silage for fattening—and it should be mentioned that the finish of the beasts given silage was always superior—it will be appreciated that beef cows in calf and in lactation would greatly benefit their calves by the tocopherol transferred from the silage, and this should be an added incentive towards using it. The use of grass silage for bulls is recommended by American workers [14], who found that it could be given at the rate of 4 lb. per 100 lb. body weight (the dry matter of the silage was 29.6 per cent), the remainder of the ration being hay. Bulls so fed did not differ significantly from comparable bulls fed on the same amount of hay plus concentrates equal in total digestible nutrients to the silage, nor was there any difference in the quantity and quality of the semen produced.

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S.M.B.

CROP HUSBANDRY

Cereals

In a paper entitled " Barley Growing in England, 1952 " (*J. Inst. Brew.*, 1953, **59,** 366-70), J. M. C. Parry has made an assessment of the total cultivated land (including hill grazing) which is devoted to barley, the results being shown for the individual counties both in tabular form and diagrammatically. The distribution of the more popular barley varieties is similarly shown. The counties growing the largest proportion of barley are West Suffolk, Cambridge, East Suffolk and Norfolk. The greatest production is in East Anglia and the East Midlands, and the highest proportion of long-strawed varieties is found in the eastern half of the country. Earl has greatly extended in popularity in the last year or so, and Plumage Archer and Spratt Archer are gradually being superseded by the Scandinavian varieties. There are signs that Kenia has reached the height of its popularity, and is being superseded

by Freja, Herta, Ymer, Maja and Carlsberg. The author, who is connected with a brewing firm, has this to say about barley varieties. " If brewers want the long-strawed varieties, they must make it worth the farmer's while to grow them. This means that at present (1952) prices they will have to guarantee at least 40s. a quarter more for them. Only in this way will the slide be stopped. After all, the farmer's first consideration is to make his farming pay, despite what the brewers and maltsters beseech him to do."

Two papers of immediate interest to cereal growers were read by agricultural merchants at a conference in Winchester in October 1953. They were " Demand for Cereals, 1954 ", by G. Loader, and " Presenting Grain for Market ", by G. B. Hopkinson. Both are reported in *Agric. Merch.*, 1953, **33,** 328-32.

C. Barclay (*Emp. J. exp. Agric.*, 1953, **21,** 190-2) describes a self-cleaning miniature thresher that deals expeditiously with samples, single ears, or pods, and needs no cleaning out between samples. The working parts are constructed from a vacuum cleaner ; the fan knocks out the grain and the separation of the chaff is performed in a simple, home-made, wooden attachment.

Potatoes

G. V. Dyke and P. R. D. Avis have recently published details of a survey of maincrop potatoes, with special reference to estimates of yield, from 1948 to 1950 (*J. agric. Sci.*, 1953, **43,** 450-5). The chief purposes of the survey, which was planned from Rothamsted and implemented by N.A.A.S. officers, were to test the official yield estimates against estimates derived from sample weights, and to examine the practices of growers and to determine any improvements which might be practicable. N.A.A.S. officers are already in possession of much of the information given in this paper, which is mentioned here because of its reference value. The main conclusions are that objective estimates of the yield of maincrop potatoes can be obtained from small samples carefully selected and dug by hand, and that the results point to under-estimation on the part of official estimates in each of the three years, the discrepancy being about $1\frac{3}{4}$ tons per acre.

In this connection, it is worth noting the conclusions arrived at from a three-year trial in southern Sweden designed to find out the amount of potatoes left on the field after different methods of lifting. (*Svenska LandarbFören. Tidskr.*, 1952, 10). Lifting was done by plough, elevator, spinner (with and without screen) and complete harvester. A substantial proportion of the crop was lost with all methods of lifting, approximately one-tenth of the crop being left in the ground. This loss consisted mainly of quite normal potatoes : so-called " small potatoes " represented only 15 per cent of the loss. Only 10-20 per cent of the total loss can be recovered by a second picking, which is a costly business.

Cereal-Legume Mixtures for Silage

A one-year trial at the Craibstone Experimental Farm has recently been reported (*J. Scot. Agric.*, 1952-53, **32,** 166-8). The purpose of the trial was to ascertain the yields of dry matter and protein, and the effect of nitrogen applications on the yields of mixed crops of oats, vetches and peas grown for silage. The oats were sown at three different rates (40, 80 and 120 lb. per acre). With each rate three different vetch-pea mixtures were added—namely, 28 lb. vetch and 28 lb. peas ; 56 lb. vetch and 28 lb. peas ; 28 lb. vetch and 56 lb. peas—and each plot was undersown with 15 lb. Italian ryegrass. Half of each mixture was dressed with 1½ cwt. and the other half with 3 cwt. sulphate of ammonia per acre. The crop was cut at four different stages of development when (1) the oats were 2 feet high, (2) the oat ears were fully emerged, (3) the top oats in the panicle were at the milky stage, and (4) the oats were ripe.

It was found that the legumes made a significant contribution only when the seeding rate of the oats was low (40 lb. per acre) and when the oats were allowed to mature, and also that in oat-legume silage mixtures, vetches are more tolerant to competition than peas. The highest yield was obtained when the oats were sown at 40 lb. per acre, dressed with 3 cwt. sulphate of ammonia per acre, and cut at the ripe stage, that is, 88 cwt. dry matter and 6 cwt. crude protein per acre.

The conclusions drawn from this trial are, first, that legumes sown in cereal-legume mixtures for silage do not always contribute as much to the dry matter and crude protein yields as is often supposed, and, second, that a cheap reliable way of producing high yields of protein may be the growing of thickly sown oats, undersowing with Italian ryegrass and cutting at the early growth stage.

C.K.
D.H.R.

MACHINERY

The Modified Brown-Duvel Moisture Test. *N.I.A.E., Report No.* 33, 1953.

The Modified Brown-Duvel moisture test has been described in N.I.A.E. Technical Memoranda Nos. 7, 9 and 52. Since these were written, the method has been used in several N.I.A.E. investigations —notably those connected with studying haymaking operations—and simple apparatus for carrying out the test has been marketed. The work described in this latest report consisted of an investigation of possible errors, and a comparison with such accepted methods as toluene distillation for grass samples, and with an oven method for grain samples.

Briefly, the method consists in heating a weighed sample of the material in an oil of high boiling point in an open vessel, and measuring the loss in weight. Fifty or one hundred grammes of the sample is usually placed in a suitable container, such as an aluminium saucepan. The sample is then covered with tea-seed oil (or rape oil); a thermometer and stirring rod are added; the whole is weighed, and heat is applied by any convenient means, a small portable stove for example. The temperature rises rapidly to about 110°C. and remains approximately constant until most of the water in the sample has evaporated. When bubbling ceases, the temperature again rises rapidly, and heating is stopped at 155°C. for green materials or 190°C. for cereals. The whole is then re-weighed, and the loss of moisture from the sample is readily obtained.

The conclusions reached as a result of the investigations are that (*a*) both tea-seed oil and rape oil are satisfactory for use in the test (samples should be preheated when used for the first time or after a long period of disuse, in order to drive off any absorbed moisture or low boiling-point fractions); (*b*) errors from weighing vessels hot are possible, but seem likely to be negligible in practice; (*c*) the test does not repeat as well as the oven method for grain, but for grass it seems more attractive for routine moisture content measurement than the toluene distillation method. Since the moisture content of green material is an important factor in many conservation processes, it seems likely that the Modified Brown-Duvel method may be of considerable value to investigators in the field. It may even find practical use on some farms where the importance of efficient conservation is appreciated.

Investigations on the Usefulness of P.T.O.-driven Trailers for Farm Transport. *Bulletin No.* 243. Swedish Institute of Agricultural Engineering, Ultuna, Uppsala, 1952. (English Summary).

An account is given of a series of investigations on the use of power-take-off-driven trailers for hauling sugar beet and lumber. In addition to timed field tests and an examination of handling characteristics in difficult conditions, fourteen farmers who used home-made power-take-off-driven trailers constructed from discarded trucks were questioned. The field tests on hauling sugar beet were carried out in southern Sweden during November.

When driving over unfavourable terrain, a tractor with a power-take-off-driven trailer could transport loads two to three times as heavy as the same tractor with an ordinary balanced two-wheeled trailer. Performance was approximately equal to that of a tracklayer with a four-wheeled trailer. It was found, however, that a light rubber-tyred tractor operating a trailer with heavy front loading—due to having the trailer wheels well to the rear—gave almost as good a performance as the same tractor with a power-take-off-driven trailer.

Wheel girdles increased the maximum pull of a light rubber-tyred tractor by 50 per cent, while half-tracks increased the pull by 100 per cent. However, fitting these devices did not result in an appreciably improved transport performance when used with trailers with very heavy front end, because performance was limited by the engine power available.

Power required was proportional to the total weight of tractor, trailer and load, and over unfavourable terrain only a total of 225 to 265 kilograms per b.h.p. could be hauled. Power-take-off-driven trailers showed to advantage when compared with trailers having a heavy front loading, only with tractors of over 25 b.h.p. Tests with different gear ratios between the power-take-off and the trailer wheels proved that running the trailer wheels a little " slower " than the tractor wheels was almost as good as running them at the same speed, but that the trailer wheels should never be run faster than the tractor wheels. Driving the trailer wheels faster is likely to overload the transmission and result in a very inefficient performance. Power-take-off-driven trailers that were heavy at the front were found preferable to the balanced type.

The farmers who had used these trailers for hauling sugar beet for a year or more were mostly satisfied with them, and found them generally durable, even though they had been made from discarded trucks. The trailer was seen to advantage when a powerful tractor was used to haul an ordinary trailer behind the driven one. By this means, with a moderate load on each trailer, a very heavy total load could be hauled off the field.

One important general finding, which explains some of the apparent contradictions which result when different types of tractors and trailers are compared, was that the coefficient of rolling resistance in difficult conditions is not constant, but increases with increasing weight. As a result of this, the ratio of drawbar pull : tractor rear axle weight was found to be 30 per cent lower for the heaviest tractor than for the lightest one tested.

Braking Equipment for Farm Tractors and Trailers. *Bulletin No.* 249, Swedish Institute of Agricultural Engineering, Ultuna, Uppsala, 1953.

This bulletin, which has an English summary and English titles to the seventy-six illustrations, deals in comprehensive fashion with new Swedish road traffic regulations and with investigations made to deter-

mine the efficiency of various tractor and trailer braking systems. Among the important findings are the following :

A simple and cheap braking system is adequate for light trailers when the total gross weight does not exceed twice the weight of the tractor. Operation of the trailer brakes can then be by a rope, or by a lever on the trailer drawbar.

With medium-weight trailers (total weight of trailer and load more than twice tractor weight), powerful trailer brakes are necessary, and operation of them may conveniently be by a hydraulic system or by a Bowden wire from the tractor. Other effective methods are by a mechanical connection from the tractor brake pedal, or by automatic device.

For fairly heavy trailers, power braking is recommended, and direct-acting vacuum brakes and electric brakes are among the types suggested. An interesting power-braking method described and illustrated is by using a hydraulic cylinder operated by the tractor's normal hydraulic lift pump. This cylinder can be attached to the trailer and operated by flexible hose in the same way as a hydraulic tipping mechanism.

The investigations made it clear that it is satisfactory to operate power trailer brakes by means of an independent control lever placed on the steering column. By this means, braking of the trailer can be adjusted, and any tendency of tractor and trailer to " jack-knife " can be avoided.

On slippery roads it is important to have a fine control of the trailer braking so that the wheels are not locked, because this may result in dangerous side skids.

With four-wheeled trailers, front-wheel brakes were found more effective than rear-wheel brakes ; but with present designs some mechanical troubles were experienced with front-wheel trailer braking systems. In hilly districts, the use of brakes on all wheels is recommended.

The use of mechanical parking brakes on two trailer wheels is advocated for all trailers.

C.C.

FRUIT

Some Effects of Orchard Factors on the Quality and Storage Properties of Apples. T. WALLACE. *Science and Fruit*, 140-61, University of Bristol, 1953.

Much research on the effects of orchard factors on the storage properties of apples was carried out at Long Ashton from 1927-38, and some of the more important results have recently been summarized by Wallace in the Jubilee volume of the Long Ashton Research Station.

VARIETIES. In addition to the well-known differences between varieties, it is found that varieties show different types of storage troubles (most of which are illustrated in the paper). Thus Newton Wonder is prone to bitter pit, scald and core flush during storage but is resistant to low temperature injury, whereas Cox's Orange Pippin and Bramley's Seedling are susceptible to low temperature injury, and Worcester Pearmain and Monarch are very resistant to flesh breakdown and core flush. These variations lead to differences in reaction to particular orchard conditions.

ROOTSTOCKS. With Bramley's Seedling and Worcester Pearmain over a number of seasons, fruit from trees on M.IX developed the most rots and those from trees on M.V the least. Results for breakdown in cold store were not so clear, but the tendency with Bramley's Seedling and Worcester Pearmain was for M.IV to give high values for breakdown and M.IX low values; with Cox's, M.IX gave higher values than M.II, with Lane's, M.IX gave low results. (In this connection it should be remembered that maturity and picking date are influenced by rootstock and may contribute to these results.)

AGE OF TREE. It is difficult to separate the effect of the lighter crop carried by young trees from the effect of the age of the tree, but it is well known that fruits from young trees tend to be larger and are poor keepers, developing bitter pit, shrivelling and breaking down.

CLIMATIC FACTORS. Poor fruit quality is associated with high summer rainfall, and also with high summer temperatures, which are conducive to water core, cork or tree pit, skin cracking and russeting, and flesh breakdown. But there was no obvious correlation between weather conditions and the storage rots and flesh breakdown of fruit that was sound when put in store.

CULTURAL SYSTEMS. The most important influence was that of grass in reducing the nitrogen content of the fruit, and in decreasing the rotting and breakdown in store. The fruits from the grassed plots also ripened more slowly after picking.

MANURING. The effects of manures on storage quality are very complex. Variations in results may be expected on different sites and under differing storage conditions, particularly as regards temperature effects on breakdown; but in many cases potash deficient fruits were susceptible to low temperature injury, although they showed low amounts of rots.

Pruning and Thinning. Light and hard pruning produced differences in the size and colour of the fruit, especially in years of heavy crop, when the lightly pruned trees carried much more fruit. In such years, the hard pruned trees showed a high percentage of flesh breakdown and a low percentage of core flush.

The larger fruit produced by drastic thinning showed an increase of flesh breakdown in store.

Fruits from light crops are usually large and frequently poor keepers, and are susceptible to bitter pit and flesh breakdown.

Bark-ringing. In general, the effects were similar to those produced by grass cover, both rots and breakdown being less in ordinary store than for untreated samples ; in low temperature store, however, fruit from ringed trees proved highly susceptible to scald and flesh breakdown, and fruits normally liable to core flush developed flesh breakdown instead.

Time of Picking. Early picking tended to increase shrivelling, whereas late picking increased rots and flesh breakdown. There was no evidence in support of the generally accepted opinion that early picking increased bitter pit, and inconclusive evidence that it increased scald.

Position of Fruits on Tree and Truss. Exposed fruits proved to be more susceptible to bitter pit than shaded fruits. In ordinary store the shaded fruits showed higher proportions of rots.

With the trusses, the terminal or king fruit appears to be more liable to lenticel-spot breakdown than laterals, but the latter shrivel more readily. In two experiments with Bramley's Seedling in low temperature store no differences in flesh breakdown were found and rots were negligible in all samples.

Size Grading. Size grading can sometimes automatically grade also for susceptibility to storage troubles. Thus in one experiment on Bramley's stored at 32°F. the largest fruits had the most flesh breakdown, whereas the smaller fruits had the most core flush.

Physiology of Growth of Apple Fruits. III. Cell Characteristics and Respiratory Activity of Light and Heavy Crop Fruits. D. Martin and T. L. Lewis. *Aust. J. sci. Res.*, Ser. B. 1952, **5**, 315-27.

One of the most important problems of the Tasmanian fruit industry is to increase the keeping quality of the large fruit demanded by the markets. Apples from light crops are known to be more susceptible to cool storage disorders than those from heavy crops, although studies of the differences between them have not shed much light on the underlying causes of their storage behaviour. The differences appear to be bound up with respiratory behaviour, but respiration per unit fresh weight shows no consistent difference between large and small fruit, and light and heavy crops. Published data suggests, however, that

respiration per unit protein may be higher in a light crop year than in normal years. Several workers have studied the size of the cells of fruits of different varieties and there are indications that differences in storage behaviour are correlated with cell size.

Martin and Lewis, therefore, studied the inter-relation of cell characteristics and respiratory activity of light and heavy crops of certain Tasmanian grown apples. Pairs of trees were selected to give fruit of the same variety of different size, and twenty fruits were picked from each. Four average fruits were selected for cell measurements ; the others were used for determining the rate of respiration, hardness as shown by a " penetrometer ", starch pattern by the iodine method, and soluble solids of the juice by refractometer, and for other analyses.

The fruits for cell measurements were halved equatorially, and sections were cut from the mid-cortex area of the cut surfaces from two positions on opposite sides. Four of these sections from each fruit were mounted for microscopical examination, and twenty-five cells from each were projected so that their volume and surface area could be computed. The specific gravity of the cells was taken as 1.1, and from the weight of each fruit and its average cell volume the number of cells per fruit was determined.

It was found that the difference in fruit size between light and heavy crops was a matter of cell size rather than number. It was also found that there was a close correlation between the respiration per cell and cell volume, both between light and heavy crops and between varieties. Protein nitrogen is also correlated with cell volume and cell surface, suggesting that the protoplasm in the cells is of constant thickness over the range of cell size studied. Apples from a light crop showed a higher respiration per unit protein than those from a heavy crop, and this may be related to the poor storage of these fruits.

The large fruit from heavy crops have been shown by other workers to differ from " off " year fruit in that the large size is due chiefly to an increase in cell number and not in cell size ; the respiration per unit protein of these fruits would therefore be lower. In practice they are found to store better than " off " year fruit. Since cell division normally ceases three to four weeks after pollination, horticultural practices that stimulate cell-division or prolong this period are likely to be beneficial, whereas excessive increase in cell size must be avoided. Unfortunately, little is known at present about the factors influencing cell division.

H.B.S.M.

GLASSHOUSE CROPS

Tomatoes. Methods of Raising Plants. *Ann. Rep. John Innes Horticultural Institution.* 1952, 23.

This report deals with developments arising out of the work by Dr. D. Lewis described in the 1951 report. Early fruiting in tomatoes largely depends on adjusting temperature to light conditions. Low temperatures are often necessary to balance growth when light is poor, but they may have two other effects : they may increase the number of flowers per inflorescence, or they may induce multilocular, misshapen fruits. Thermostatic control of air temperature in glasshouses has a bearing on the light-temperature reaction; that is, the minimum temperature is also the mean night temperature. Artificial light is another factor to be integrated with temperature control. Preliminary work shows that the onset of the temperature-sensitive period affecting the inflorescence size is determined by the rate of development of the seedling. The experiments reveal a complex situation involving critical thermoperiodic and photosynthetic effects at specific stages of plant development, which may have an important bearing on commercial tomato production.

Some of the findings mentioned in the 1952 John Innes report are described in more detail in " Temperature and Truss Size in Tomatoes " by A. Calvert (*Grower*, 1953, **39**, 524).

Artificial Illumination of Seedlings. *John Innes Leafl.* No. 11, 1952.

Some of the methods of making good most of the deficiency of natural light in the winter months by the use of artificial light are given in this leaflet. From several different lamp types the high pressure mercury vapour lamp was selected for experiments, which were mainly concerned with illumination in the propagating house, where a large number of seedlings can be packed under each lamp. One set of lamps was used to illuminate two batches of seedlings. This was done by suspending the lamps on rails running lengthwise over the plant bench, first for 12 hours over the plants at one end, and for the next 12 hours over those at the other end. Thus the lamps are alight continuously, and each batch of plants is illuminated, partly during the day and partly during the night. Whatever the period of illumination, it is most important that tomatoes have at least six hours of unbroken darkness in a day, or leaf chlorosis and distortion will occur. This does not apply to cucumbers, which can be illuminated for 24 hours daily without injury. The usual period of illumination recommended for commercial conditions is about three weeks, and in the experiments with maincrop tomatoes at Merton, it appears that, with the use of artificial light, the earliest pickings can be increased by 50 to 70 per cent, and the total yield by 10 per cent.

E. S.

CROPS AND PLANT BREEDING

Physiological Characterization of Wheat Varieties

Varietal classifications based on physiological characters not only supplement morphological classifications but are often of more direct agricultural interest. Gassner [1] reports vernalization experiments with German wheat varieties, carried out with the aim of classifying them by strength of cold requirement. He recommends vernalizing the seeds in the presence of free water in sand or on filter paper at a temperature of 1° or 2°C. At this temperature the response is more uniform from plant to plant if a preliminary soaking is given at 18°C. for one or two days. The durations of treatment he recommends are thirty, forty-five and sixty days; for winter wheats the treatments should end so as to allow simultaneous planting at the beginning of April; for spring varieties the end of May or beginning of June is preferred. Soaked seed is planted as control.

By comparison of the effects of the different treatments with each other and with the controls, he could distinguish seven groups of varieties. These, with an indication of the strength of the cold requirement and a typical variety for each, are as follows: (*a*) none, Heine's Peko; (*b*) weak, Strube's Roter Schlanstedter; (*c*) clear, Derenburg Silber; (*d*) fairly strong, Heine's IV; (*e*) strong, Strube's Dickkopf II; (*f*) very strong, Breustedt's Werla; (*g*) extremely high, Carstens V.

A preliminary classification of wheat varieties grown in the United Kingdom, based on their behaviour after successive spring sowings, is given by Elliott, Greenwood and Reiss [2]. According to them, the English and French winter varieties can be safely sown up to mid-February; Rivet is an exception and resembles the Dutch and Scandinavian varieties in that it cannot be recommended for sowings after the end of December. Bersée, Atle and Meteor can be sown in March, and for April sowings Fylgia and April Bearded are available, though earlier sowing is recommended even for them.

Tetraploid Rye

In an earlier review (this JOURNAL, 1951, No. 12, 160), reference was made to Müntzing's description of tetraploid Steel rye as not inferior in yield to the diploid from which it was derived. Owing to the sterilizing effect of diploid rye on adjacent tetraploids, their yields had to be compared indirectly, against a standard wheat variety. Similar trials were carried out in Denmark in 1950-52 at four locations, comparing diploid Petkus, tetraploid Petkus and tetraploid Steel with Scandia wheat. The preliminary report [3] is less favourable than Müntzing's to the tetraploid. Diploid Petkus out-yielded wheat by 5 to 8 cwt. per acre, but the average yields of the tetraploid ryes in twenty-one trials were just under that of the wheat.

Proctor Barley

Bred by Dr. G. D. H. Bell at the Cambridge Plant Breeding Institute from a cross between Kenia and Plumage Archer, this new variety of spring barley is briefly described in a leaflet issued by the N.I.A.B. [4]. In thirty-seven trials run by the N.I.A.B. at seventeen different centres over three years, Proctor has significantly outyielded Kenia in all but nine : in no case was Proctor significantly outyielded by Kenia. The average difference in favour of Proctor was 15 per cent. Kenia was outyielded both at high and average levels of productivity. In small-scale trials at the Plant Breeding Institute, Proctor outyielded Spratt Archer by an average of 16 per cent over five years.

The grain of Proctor is about the same size as that of Kenia, but malting tests show it to be superior in quality, with a lower nitrogen content, a higher extract and a better appearance. In many trials the quality has been equivalent to that of Spratt Archer, and in some cases, it has been superior.

Compared with Spratt Archer, Proctor is shorter and stronger in the straw, and four or five days earlier. Compared with Kenia, it is about equivalent in straw height and standing capacity, and three or four days later. The ear, borne on a short neck, is longer and denser than Kenia but laxer than Plumage Archer.

Identification of Red Clover Types

Hawkins [5] has summarized the results of extensive work on this problem, arising in the first place from the requirements of field certification. Broad red clover flowers about ten days earlier than single-cut, which in turn is ten to fourteen days earlier than late-flowering red clover (Cornish Marl and Montgomery). The number of internodes on main stems, from the first expanded internode to the terminal inflorescence, is closely correlated with flowering date and is more useful in practice, for it can be determined at any time after the flower buds become visible. The differences between types are quite clear ; e.g., in the 1950 plots, six stocks of broad red averaged 6.68 ± 0.80 internodes, twelve single-cuts averaged 10.95 ± 1.36, three Cornish Marls 14.13 ± 2.11 and three Montgomerys 15.13 ± 1.44.

Hawkins also gives practical instructions on making counts and illustrates their use in field inspection, where the effects of fertility and management have to be taken into account. He also gives internode counts for a large number of imported red clovers.

Cyanide Production in White Clover

In the sixth paper of the New Zealand series on cyanogenesis in *Trifolium repens*, Corkill [6] reports briefly on several experiments bearing on the practical importance of this character, which depends on the simultaneous presence in individual plants of cyanogenetic glucosides (linamarin and lotaustralin) and of the enzyme which hydrolyses them. A single Mendelian dominant is associated with glucoside

production and another independent one is associated with enzyme production. In a cross between a vigorous New Zealand white clover plant and a less vigorous Kent individual, the F_2 gave good 3 : 1 segregations in respect of both glucoside and enzyme. On comparing the yields of plants with and without glucoside, Corkill found no significant difference ; the same applied with respect to enzyme.

A strain having enzyme but no glucoside was selected out of New Zealand pedigree white clover, and was compared for yield with pedigree, a certified " natural " strain and an uncertified strain. The " enzyme-only " strain yielded as well as, or better than, the pedigree, and significantly better than the others. In another trial three strains were compared for palatability to sheep—the " enzyme-only " strain, a highly cyanogenetic strain and New Zealand pedigree, which is also cyanogenetic. In 13 grazings over a period of fourteen months, no evidence was found of any preference on the part of the sheep, though rabbits and slugs showed a distinct preference for the " enzyme-only " strain.

In the certification of New Zealand white clover seeds, samples of seedlings are required to give a strong positive reaction in a standard picrate paper test for cyanide. Corkill reports that in testing the present cyanogenetic pedigree strain, unless at least 24 per cent of a glucosideless adulterant is present, it cannot be detected by a weakening of the reaction. If the situation were that the pedigree strain contained enzyme only, then adulterants containing glucoside could be detected in as low a proportion as 2 per cent. He suggests that it might, therefore, be worth while to change the pedigree strain to an " enzyme-only " basis, though recognizing that the change-over might cause serious difficulties in the white clover seed industry in New Zealand.

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J.L.F.

DAIRY BACTERIOLOGY

The Inhibition of Micro-Organisms by Raw Milk. I. The Occurrence of Inhibitory and Stimulatory Phenomena. Methods of Estimation. J. E. AUCLAIR and A. HIRSCH. *J. Dairy Res.*, 1953, **20,** 45.

It has been known for many years that raw cow's milk is inhibitory to various bacteria, notably *Streptococcus pyogenes*. The inhibitory substances appear to be active only under aerobic conditions. The nature and properties of these substances, called " Lactenin ", were investigated by the authors.

First they proved that Lactenin was not lysozyme and then established that it comprised at least two inhibitory fractions. The effect on organisms in milk was the resultant of the action of these two fractions and a stimulatory substance which was also present.

One inhibitory fraction (L_1) occurred mainly in colostrum, and the other (L_2) mainly in milk. The inhibitory action was greatest when the two acted simultaneously.

L_1 was most stable at *p*H 6-6.5, and 90 per cent was destroyed at 68°C. L_2 was most stable at *p*H 7.0, and 95 per cent was destroyed at 74°C. The stimulatory substances in milk and especially in colostrum allowed *Str. agalactiae* to overcome the inhibition due to L_1 and L_2.

II. The Separation and Electrophoretic Examination of Two Different Inhibitory Fractions. J. E. AUCLAIR and N. J. BERRIDGE. ibid., 1953, **20,** 370.

By fractional precipitation with acetone the two substances L_1 and L_2 were concentrated and separated into highly active, though still impure, components.

This paper, together with the one above, goes far towards the solution of the problem of the effect of raw milk on the growth of bacteria likely to comprise the population.

The Removal of Bacteria from Glass Surfaces with Calcium Alginate Gauze and Absorbent Cotton Wool Swabs. JOAN M. BARNES. *Proc. Soc. appl. Bact.*, 1952, **15,** 34.

It seemed from the work of Higgins (*Monthly Bulletin of the Ministry of Health Laboratory Service*, 1950, **9,** 49), that calcium alginate wool had certain advantages over cotton wool swabs for estimating the bacterial population of infected surfaces. The author, on comparing the efficiencies of calcium alginate wool, gauze and absorbent cotton wool, found that the numbers of organisms present probably did not affect the result, but it appeared that alginate was less effective when numbers were small.

The error due to imperfect removal (or recovery) of organisms by cotton wool swabs was equalled by the imperfect pick-up with alginate. The recovery from cotton wool swabs was improved by using Calgon in the rinsing fluid.

Swabs carrying small numbers of organisms when stored in the refrigerator yielded better recoveries than when plated immediately. This effect was less obvious when larger numbers of organisms were present.

Some Aspects of Design and Operation of Vertical Laboratory Autoclaves. C. C. Thiel, H. Burton and J. McClemont. *Proc. Soc. appl. Bact.*, 1952, **15,** 53.

For many years bacteriologists have been aware of the dangers of varying treatments of media during sterilization, and especially of the effects on bacterial growth of overheating.

The design of autoclaves has been such as to make consistency difficult. The authors having demonstrated again the evils of overheating media, suggest that in an 18-inch laboratory autoclave the sterilization ought to be controlled to $\pm$ 1°C. and $\pm$ 1 minute.

When, and only when, the internal atmosphere of the autoclave was virtually air-free, the time/temperature curves of small volumes of liquid or solid media corresponded closely to those of the atmosphere of the autoclave. It was found difficult to expel air when the load consisted entirely of media in test tubes. The maximum satisfactory load was 8 baskets, 6 inches $\times$ 6 inches $\times$ 6 inches, of test tubes on an open false bottom with spacers between the tiers. A mercury-in-glass thermometer fitted in or near the vent was found to be the best practical means of finding when the exhaust steam was air-free. When this has been achieved, closing of the vent is delayed for 3 minutes, after which no local air pockets will persist within the load.

The treatment for larger bulks of media was also determined.

Full working details of satisfactory gas burners and control equipment are given in the paper together with performance tests for the use of bacteriologists.

This is a most valuable paper and is likely to have far reaching effects.

A Comparison of the Most Probable Numbers of Coliform Bacteria and Enterococci in Raw Sewage. Warren Litsky, M. J. Rosenbaum and R. L. France. *Appl. Microbiol.*, 1953, **1,** 247.

A simple routine test for enterococci might be of value as an indication of water pollution to supplement or substitute tests for the coliform group, many of which, unlike enterococci, are non-faecal in origin.

Azide dextrose broth was inoculated from dilutions as for coliform organisms and incubated at 37°C. for 48 hours. Turbid tubes were then taken as positive and confirmed by transfers to ethyl violet azide broth. In sewage from settling tanks a positive correlation of 0.9 was found for coliforms and enterococci in winter, spring and summer.

The density of the coliform population was 13.3 times that of enterococci.

The Stability of Some Bacterial Enzymes toward Heat and Chemical Bactericides. W. H. Oliver. *J. gen. Microbiol.*, 1952, **7**, 329.

Heat-resistant enzyme systems which can function after death of the organism are widespread among bacteria. The decarboxylase enzymes of the lactic acid bacteria ceased activity above 80°C. (the organisms themselves being killed) but resumed activity at low temperatures. This enzyme system is also stable to $HgCl_2$ and surface-active bactericides. These findings may be important in pasteurization and dairy manufacture, and may supply further reasons for insisting upon the hygienic production and handling of the raw milk.

Aerobic Treatment of Dairy Wastes. N. Porges, L. Jasewicz and S. Hoover. *Appl. Microbiol.*, 1953, **1**, 262.

The biological oxygen demand of dairy sewage is notoriously high. In experiments with a " synthetic " dairy waste with aeration, it was found that 62.5 per cent of the organic matter was rapidly converted to cell material and the balance oxidized for energy requirements. On continuing aeration after the initial rapid growth phase, auto-digestion by endogenous respiration occurred. This aeration process converts dairy wastes with high oxygen demand to cell substances of low oxygen demand. The paper should be read in full.

A.T.R.M.

POULTRY HUSBANDRY

Breeding

Most pedigree breeders will have had experience of a bird which under the trap nest gives no record for egg production or, at most, an occasional egg, yet has the appearance of a bird in full lay, as shown in the customary bleaching of the pigmentation of the bird and the head appearance. This condition is discussed in a paper entitled " Normal Ovulation in Non-laying Hens " by R. K. Cole and F. B. Hutt (*Poult. Sci.*, 1953, **32**, 481-92). The writers survey several causes leading to absence of laying, including disease conditions and incomplete reproductive tracts. The main interest, however, centres on those birds which on post-mortem examination reveal a fully developed, and apparently fully functioning, reproductive system. It is suggested that it is possible that the stimulating action relating to portions of the ovarian tract induced by hormone secretion may be absent in these birds, and the inability of part or all of the oviduct to engulf the ovum may lead to the deposition of yolks within the body cavity. If disease-infected material is not present, egg peritonitis does not supervene

and the yolk is reabsorbed with a certain loss of pigment. The writers indicate that there is some evidence from differences among sires and strains that genetic factors may be involved. The conclusions are that visual inspection for laying characteristics may lead to errors with some birds, which may form as many as 3 per cent of the flock.

Dealing with a subject of topical interest is a paper on " The Relative Influence of Egg Size, Age at Sexual Maturity and Mature Body Weight on Growth to Twelve Weeks of Age " by G. F. Godfrey, C. Williams and C. E. Marshall (*ibid.*, 496-500). These writers point out from the data presented that the influence of egg size is negligible at the " broiler " stage, that is, around twelve weeks, but that it exercises a major influence over chick weights up to an age of two weeks. Beyond that age the effect diminishes when mature body size and age at sexual maturity begin to exert an increasingly greater influence. The effect of mature body size increases at a faster rate than that of age at sexual maturity. The influence of the three factors (egg weight, age at sexual maturity and mature body weight) account for about 36 per cent of the variation observed in body weight at twelve weeks old. The authors do, however, give a warning on practical grounds against too easy an acceptance that small eggs may be set for the production of " broilers ", as egg size has no appreciable final influence on the size of the twelve-week-old bird. They point to the relationship between egg size and hatchability and consequently the obvious dangers of the practice, and also to the inability of small chicks to withstand the same degree of dehydration as larger chicks during transit.

On a related subject is an article on " Table Poultry Production " by R. Coles (*J. Sci. Fd Agric.*, 1953, **4,** 532-9). The writer presents a detailed study of the growth rates and food conversion rates of a number of birds from day old to 20 weeks, and concludes, on the basis of this data, that the 12- and 18-week stages are the most suitable slaughter periods for economic table poultry production.

Disease

In " Studies on Disinfection of Eggs and Incubators " by J. E. Lancaster and W. E. Crabb (*Brit. vet. J.*, 1953, **109,** 139-48), certain conclusions are reached of practical interest to the hatcheryman with regard to Salmonella. When *S. pullorum*, *S. thompson* and *S. typhimurium* were placed on the surface of a hen's egg, the Salmonella disappeared rapidly from the shell under conditions normally found inside the incubator. At room temperature the organisms survived for approximately 21 days. It is suggested that the rapid death of Salmonella under incubator conditions might be due to the drying effect of these conditions, and it is also stressed that in this situation penetration to the albumen of *S. pullorum* and *S. thompson* occurred infrequently. It is concluded that external contamination of a naturally clean egg with these two Salmonella would appear an unlikely means of introducing infection when a separate hatching compartment is in use.

Avian leucosis (including fowl paralysis) still remains responsible for a large proportion of the mortality in this country's flocks. In an article entitled " The Interaction of Genetic and Environmental Influences affecting the Incidence of Avian Leucosis " (*Science.*, 1953, **117,** 695-7), F. B. Hutt and R. K. Cole discuss one prime difficulty facing those who breed for resistant strains : namely, the uncertainty the worker must experience with regard to the degree of exposure to the disease, even though conditions under which the birds are brooded and reared do not vary from year to year. That such variations in the degree of exposure do take place seems obvious from the otherwise inexplicable year-to-year variations in the mortality from the disease with both susceptible and resistant lines.

The writers stress the desirability of rearing in isolation and as far away from adult stock as possible, to reduce the incidence of the disease with stock which may not have a high degree of resistance. It is accepted by them that ideal isolation conditions may not be within the compass of most poultry-keepers, but a combination of what is within practical bounds, allied to stock having some measure of resistance, should reduce losses from the disease far below that probable if these precautions are ignored.

One special aspect of the same problem is dealt with in " Tests in Different Environments of Fowls Genetically Resistant to Leucosis " by D. F. King, R. K. Cole, F. B. Hutt and G. J. Cottier (*Poult. Sci.*, 1952, **31,** 1027-9). An account is given of two flocks far apart and both bred for resistance to leucosis. The flocks were exchanged between the stations but continued to demonstrate resistance. This result can be considered as an indication that strains bred for leucosis in one district will prove useful in that respect in others.

Nutrition

Much doubt has been cast on the value—and possible danger—of feeding antibiotics to adult laying stock and breeding birds, as opposed to chicks intended for the table. The subject is considered in a paper on " The Effect of Prolonged Feeding of Antibiotics upon the Performance of Laying Hens " by J. F. Elam, R. L. Jacobs and J. R. Couch (*Poult. Sci.*, 1953, **32,** 792-5). It was found that the prolonged oral administration of antibiotics increased egg production and hatchability. Intramuscular injection of the antibiotic failed to show any improvement in these factors, but an improvement was noted when the antibiotic was injected in water or in oil. The writers suggest that prolonged feeding of the antibiotic either produced a flora in the intestinal tract which was more favourable for egg production and hatchability, or made available a nutrient which might promote an improvement in these characters. It should, however, be mentioned that a recent investigation in this country, details of which are to be published shortly, did not demonstrate the improvement noted by Elam and his colleagues.

R.C.

COMMONWEALTH AGRICULTURAL BUREAUX PUBLICATIONS

Institute of Entomology

In addition to the regular publications, two occasional publications have recently been issued. They are :

Injurious Insects of the British Commonwealth. J. W. Evans, 1952, 30s. This work outlines the environmental conditions and principal crops of each country and lists the injurious insects under crops and also under orders and families. Notes on each species are given with references. The book includes sections on weed control by insects, plant quarantine, virus vectors, insect control and research needs.

List of Sugar Cane Insects. H. E. Box, 1953, 15s. The first part of this publication is a catalogue of the insects and mites that have been recorded on sugar cane. It is in three columns : the first is a list of the pests in systematic order, including their synonyms ; the other two show the countries in which they have been recorded on sugar cane and, if known, the parasites and predators that attack them.

The second part is a similar catalogue of the parasites and predators ; it shows their hosts, the countries in which they attack particular hosts, and those into which they have been introduced.

A bibliography of the principal works consulted, and indexes to countries and genera, are given.

Bureau of Animal Breeding and Genetics

A World Dictionary of Breeds, Types and Varieties of Livestock. I. L. Mason, 1952, 30s. Contains over four thousand entries, divided according to species (horse, cattle, sheep, pig, goat and buffalo). Each breed is entered under, and cross-referenced to, an English name, which is followed by English and foreign synonyms and such essential information as place of breeding, breed characters and origin.

Bureau of Plant Breeding and Genetics

The Commonwealth Bureau of Plant Breeding and Genetics at Cambridge keeps plant breeders regularly informed of developments in their subjects. The information is made available in a variety of different forms. The most important is **Plant Breeding Abstracts,** a quarterly journal containing abstracts of current literature throughout the world. All publications having a direct or indirect bearing on the breeding of economic plants are mentioned ; the fields covered include genetics, cytology, evolution, practical improvement by selection and by more modern methods, such as induced mutation and polyploidy, the use of

hybrid vigour in raising yields, and the application of interspecific crosses to utilize the valuable genes of wild and indigenous floras. Not only the commoner crop plants are considered but also vegetables, temperate and tropical industrial plants and fruits, and even forest trees. A large section is also devoted to the genetics of micro-organisms, such as fungi, bacteria and virus, which are of interest both theoretically —as material for study of the basic principles of heredity—and practically—for producing improved strains for brewing and other industrial purposes, and also for building up disease-resisting forms of agricultural plants.

A special feature of *Plant Breeding Abstracts* is that works published in the more unfamiliar languages are abstracted extensively. Readers are able, for instance, to follow the important contributions of Japanese investigators to genetical and cytological theory, and to the improvement of special crops such as rice, and the more controversial issues, as the recent genetics controversy in the Soviet Union. The last volume contained abstracts in English of articles written in thirty-one different languages.

Readers are kept up to date on recent developments by two further sections : the Book Reviews, which present objective criticisms of all the more important books and monographs published on the subject; and New Journals, in which readers are informed promptly of the appearance of any new periodical publication in the above-mentioned fields, with indications of the nature of its contents and how to obtain it.

An author and classified subject index are included in the subscription price for each volume.

Special publications are issued from time to time on subjects of particular interest. The one on the Russian genetics controversy is well known. The last to appear was the eighth list of *New and Promising Varieties Recently Described in the Literature*. The new issue covers fifty-one pages and contains a list of all the most interesting varieties of crop plants, fruits, nuts and vegetables that have been described in the technical literature during the last four years. Details are given of the main characteristics of the varieties listed, their name and origin, and sources from which further information and samples of seed can be obtained.

The list thus constitutes a complete cross-section of the practical results of plant breeding in all parts of the world in recent years and is an indispensable reference book for plant breeders, seedsmen, practical farmers and horticulturists who wish to keep abreast of modern developments in plant improvement.

Copies of all bureaux publications can be obtained from the Central Sales Branch, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks.

PROVINCIAL NOTE

SOME EXAMPLES OF BREED CHANGES IN SHEEP

H. R. Kirby

National Agricultural Advisory Service, Yorks and Lancs Province

The men who pioneer in any new breed or type of animal are probably influenced entirely by their own conception of commercial worth, and their early work is usually done in the face of a good deal of uninformed criticism. Such criticism can be very intense, even to the point of bitterness, when loyalty to a local breed is involved. But if a new type can outlive this phase and prove its superior commercial worth, according to the requirements of the day, progress can be, and often is, very rapid. Fashion, influenced by price, then plays its part, bringing in those who just follow fashion.

Decline in a breed, both in popularity and in usefulness, usually begins when breeders become over-occupied in placing too much emphasis on show-yard fancy and so fail to foresee changes in market requirements or to notice the rise of a competitor breed. The whole field of livestock breeding is full of examples of going too far, that is, of over-emphasizing some desirable character to the point where it becomes commercially detrimental. Well-known examples of it with cattle are the legs of the Clydesdale, " vessel " breeding in the Ayrshire and extreme " blockiness " in some beef breeds. In going too far breeders tend to forget other equally valuable characters. Sometimes they see the red light in time to be able to undo some of the harm.

Changes which occur on the national scale can be matched by similar local changes. This is clearly illustrated in this province by the changing pattern of the sheep population during the past thirty years.

The Swaledale on the Hills

Middle-aged men can remember when Scotch Blackface shearlings came down in large numbers for breeding half-bred lambs on the Pennine Hills. They came as far south as the Skipton-Settle area and also became the breed of the Cleveland Hills.

About thirty years ago the Swaledale men standardized their type and organized themselves into a breed society. From that time the Swaledale gradually pushed the Blackface right out of the Yorkshire Pennines and, it is said, almost entirely out of the Pennines too. The Cleveland Hills, formerly entirely Blackface, are now more than half Swaledale, the change having been brought about by the continued use of Swaledale rams.

There can be no argument that as a mutton sheep the Blackface is much superior to the Swaledale, being blockier, shorter on the leg and with more development over the shoulder. The Swaledale is built more like a dairy cow, longer on the leg and finer on the shoulder—a much less impressive sheep in the show-ring. But on the hill the Swaledale men claim that their sheep is more active and, therefore, a better forager. Consequently, it makes a better recovery after storms and will put more energy into rearing a lamb. Also, today it pays better to breed for a draft ewe than for a wether lamb. These may be some of the reasons why the Blackface has retreated before the Swaledale.

A pocket of sheep of the Blackface type—the Rough Fell or Kendal Rough—remains on the hills to the north-west of Sedbergh, but these hills are not strictly Pennine. They are of a much older formation and are markedly different in many ways. Lacking variety of herbage—there is little heather and no cotton-sedge—they are called upon to winter the ewe flock only until January, when the ewes are brought down to low ground. It may well be that the qualities of the Swaledale would not find full scope in this system of management.

The Swaledale has also spread into the Lake District. It has met there a breed which is reputedly hardier still—the Herdwick. Some people argue that the Herdwick is an example of putting too much emphasis on a good character—hardiness—and, in doing so, overlooking other good characters. The Herdwick lacks size and usually does not have a lamb until it is a two-shear. The Swaledale does not grow into a good Swaledale on the Lakeland Hills, but those who work with them claim that it has more size and matures earlier than the native Herdwick.

Just as the Swaledale has pushed other breeds, it is in its turn being pushed. This development has come about comparatively recently, and it may be said that it points again to the danger of putting too much emphasis on a good character. The Swaledale has a very tight " bind " or undercoat which does not blow up and expose the skin. When the breed type was set, great stress was laid on " bind " ; sheep with more wool but a less accentuated " bind " were not accepted. There were other men who preferred the latter type and they formed themselves into a society, calling their sheep " the Dalesbred ". At a distance the Dalesbred would look very similar to the Swaledale, but on closer inspection it has a longer, more " purly " outercoat. This character is dominant. In recent years the Dalesbred draft ewe has become very popular for breeding half-breds (Mashams). There are some very keen men among the half-bred breeders who place great emphasis on fleece in their product. For this reason some of them much prefer to work with the Dalesbred as a base. The price paid for Dalesbred draft ewes has had its influence and from an area roughly centred on Settle it has begun to oust the Swaledale. This movement may not get very far because, in the face of competition, the Swaledale men are now breeding for more outercoat.

At one time in the south of the province, in the Sheffield-Penistone area, there was a large, horned hill sheep with a white face. It is now

known as the Whitefaced Woodland and today, it is said, only one pure-bred flock remains. The ewes were said to be a little lacking in milking and mothering qualities, but size probably hastened the almost complete disappearance of the breed when smaller joints were wanted. But if size drove it out, size has also brought it back into the picture during the last ten years in the hills behind some of the industrial areas. In these hills sheep are run rather thinly with a fair proportion of wethers. Whitefaced Woodland × Lonk rams have been used by several men, mostly on Lonk ewes. Two and three shear wethers bred in this way grow to remarkable weights on the hill if run thinly; they have been known to kill out at over 100 lb.

The Teeswater on Marginal Lands

Changes in the sheep population have not been limited to the hills. The half-bred of the province, the Masham, largely produced in marginal areas, is now sired almost entirely by the Teeswater instead of by the Wensleydale. Nobody appears to know the origin of the Teeswater; it is obviously of Wensleydale type and has no doubt existed in Lower Teesdale for a very long time. It has not been bred to conform to flock-book standards. The Teeswater has risen to popularity and maintains its place entirely on the merits of its half-bred progeny. Probably no other breed is progeny-tested to the same extent. But it is progeny-tested only as far as marking and fleece characters are concerned. Both these characters can be seen in the new-born lamb, so that the breeding merit of a ram can be quickly assessed. The vogue of the Teeswater may be as transitory as the Wensleydale men assert it will be, if its popularity is to be based only on "fancy" points in its half-bred daughter. The men to decide that will be those who buy Mashams to produce fat lamb from lowland grass. In fairness to the Wensleydale it should be pointed out that the ram is still used on Masham ewes to produce "twice-crossed" lambs destined for feeding off on turnips.

Until recently the Teeswater has not been shown as a pure breed. Its critics would say that it is not fit to show. But it is now beginning to appear in the show-ring, and that may be the beginning of the end of the Teeswaters' reign.

In contrast to all that has just been said, Bakewell's Leicesters are still bred in considerable numbers on the Wolds of the East Riding.

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